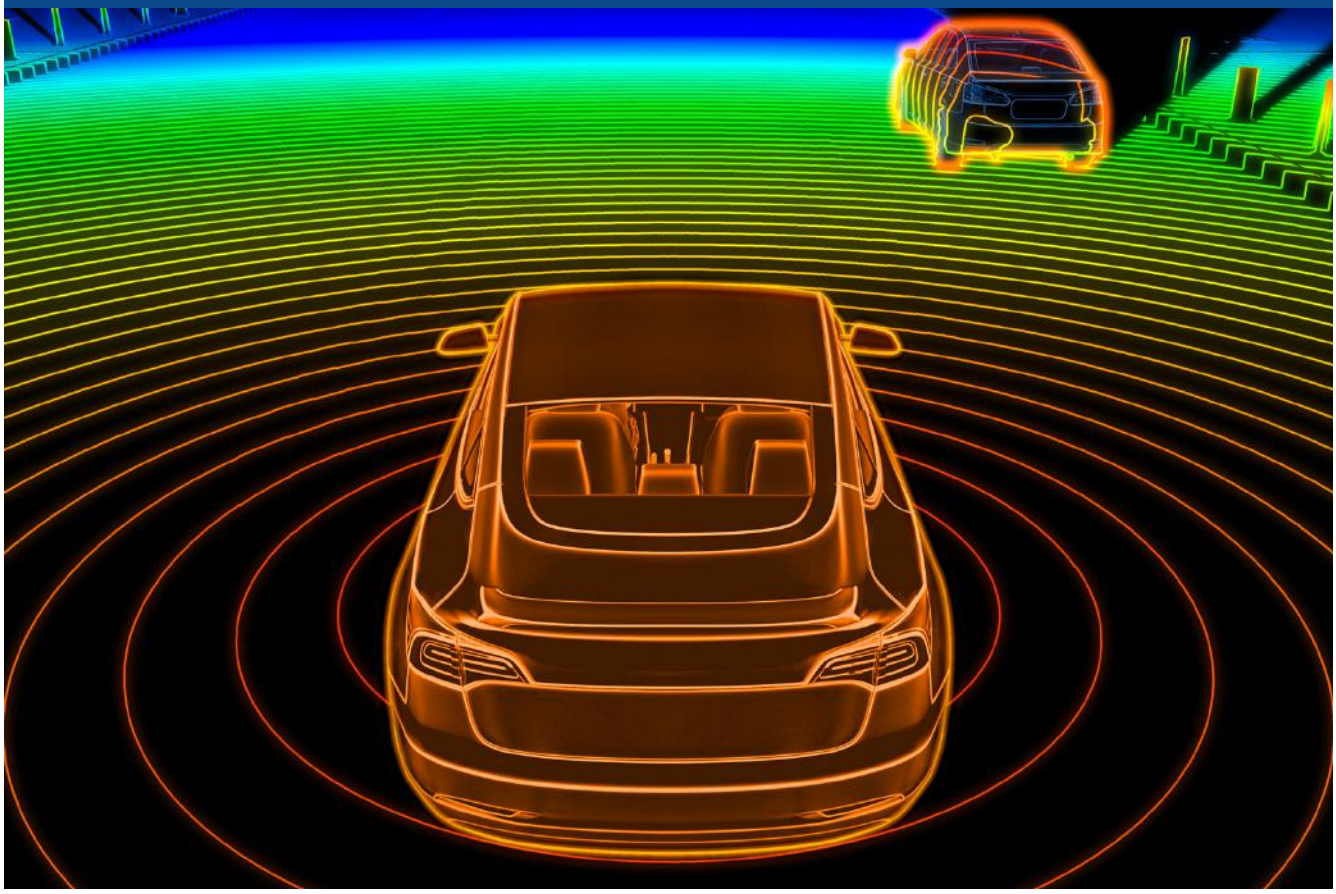
DVN

Sensing & Applications

# Monthly newsletter #3.1

MARCH 5, 2025



**EDITORIAL**

# Chinese radar suppliers are emerging


Chinese radar suppliers are hitting the market and offering the whole range of products incl. 4D radar solutions. You will find the details in the special report on the automotive millimeter-wave radar (MMW) industry in 2024. China's passenger car radar market was valued at C¥5.82bn in 2023, with a year-on-year increase of 13 per cent. Front radars account for around 60 per cent of the overall market. The main suppliers of forward radars in China are Bosch (30 million units sold end 2024), Continental, and Denso, although their market share is declining as Chinese domestic suppliers like Sensortech, Cheng Tech, and Huawei ramp up.

In this edition, you will also find insights about the fusion architectures and a detailed program with speakers at the AEB workshop in Detroit.

**Next DVN - Events 2025**

- AEB Workshop: US AEB per FMVSS 127 (Detroit, 9-10 April)
- EAC Lidar Tech Expo (Hangzhou, China, 4-6 June), co-hosted by DVN
- 8th DVN ADAS Sensing Conference: $L^{2+}$ and NOA applications (Wiesbaden, Germany, 17-18 September)

We're ever so glad you're here with us in the DVN-Lidar community. Enjoy this newsletter!

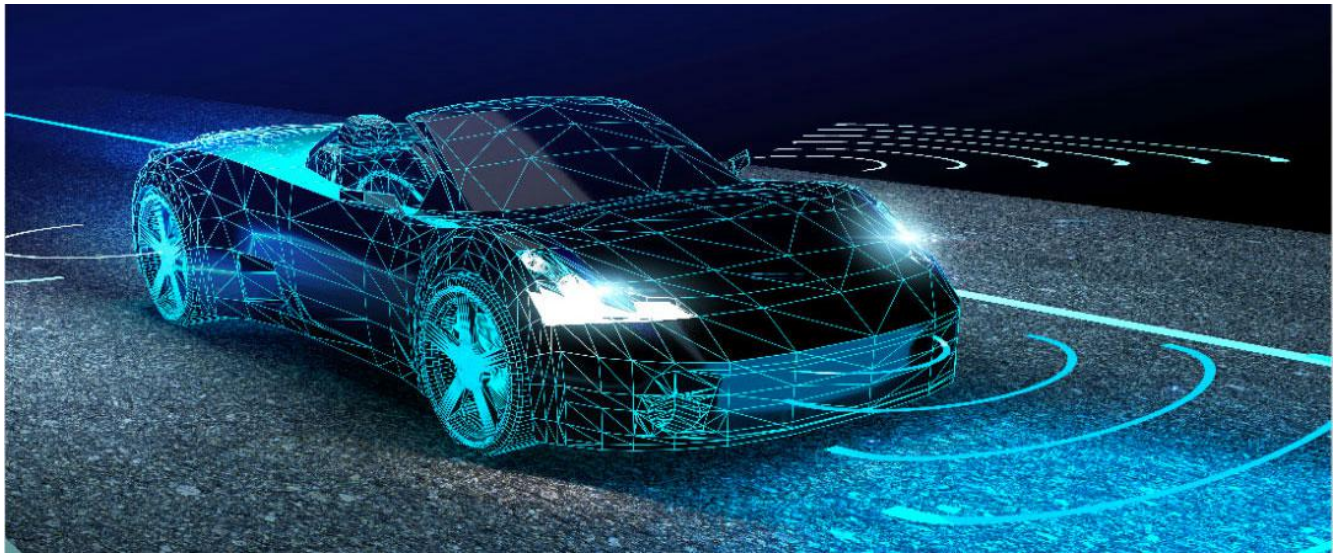
All best,

**Alain Servel**

DVN-ADAS Sensing adviser

SPECIAL REPORT

# Automotive Millimeter-Wave Radar Industry: 2024 Status in China

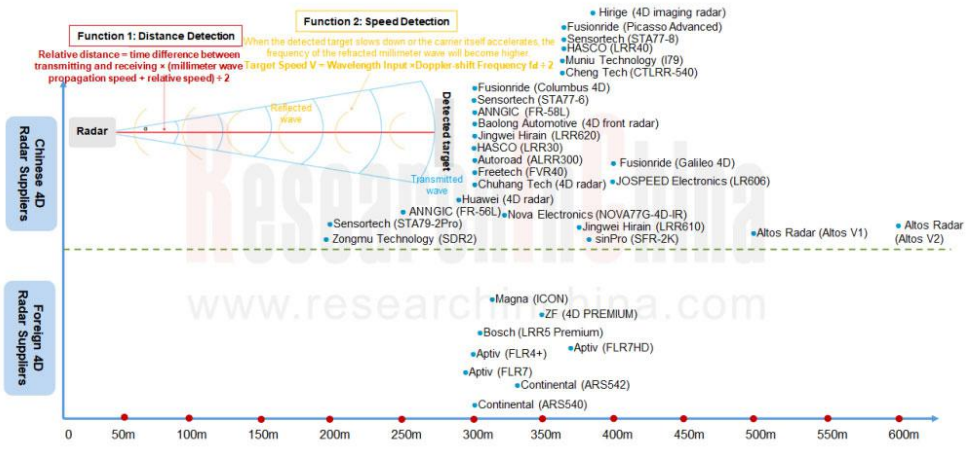


## Based on data from ResearchInChina

In China, the development of mass-produced 4D imaging radars accelerates, and the growth of domestic suppliers increases. Advanced intelligent driving systems, such as urban NOA, encounter more complex driving environments and roads. This requires enhanced capabilities for the perception system, including a longer detection range, a wider detection angle, and higher accuracy. Radars, as part of the perception system, perform reliably in various weather conditions like rain, snow, fog, and low-light environments. High-performance 4D imaging radar can improve the overall perception capability of autonomous driving systems.

China's radar market value hovers over C¥6bn for 2024, and domestic radar suppliers begin to grab higher market share.

**Main Chinese and Foreign Automotive 4D Radar Products Map**




Source: ResearchInChina

According to ResearchInChina's data, considering the industry average price of front/corner radars and their installations, China's passenger car radar market was valued at C¥5.82bn in 2023, showing a year-on-year increase of 13 [er cemt. From January to July 2024, the market was valued at C¥3.01bn, reflecting a slight increase of 3.4 per cent compared to the same period in the previous year.

Front radars hold high value and have the most installations, accounting for approximately 60 per cent of the overall market. Rear corner radars come next, with a market size of C¥1bn from January to July 2024, representing over 30 per cent of the overall market. Front corner radars comprise about 7 per cent of the overall market, while rear radars are rarely used, constituting less than 1 per cent of the market.

**Relationships between Foreign Radar Suppliers and TOP3 OEMs, Jan-Jul 2024**

| Radar Supplier | Supported OEM (TOP3) | |
|---|---|---|
| | Front Radars (Incl. 4D Radars) | Corner Radars |
| Bosch | Volkswagen, Audi, Honda | BYD, Volkswagen, Denza |
| Continental | Volkswagen, BMW, Mercedes-Benz | Toyota, Nissan, Xiaomi Auto |
| Denso | Toyota, Honda, Mazda | Toyota |
| Aptiv | NIO, Ford, Lincoln | BMW, NIO, Haval |
| ZF | MG, Dongfeng Aeolus, Rising Auto | |
| Veoneer | Volvo, Geely, Lynk & Co | Mercedes-Benz, BYD, Honda |
| Valeo | | Nissan, Hyundai, EXEED |
| Hyundai Mobis | Hyundai, Kia | Hyundai |
| FORVIA Hella | | Volkswagen, Cadillac, Buick |

Source: ResearchInChina

Bosch, Continental, and Denso are the top three front radar suppliers in China, with a combined market share of more than 70 per cent. But Chinese domestic suppliers are ramping up and gaining market share. The combined share of Bosch, Continental, and Denso has trended from 84.1 per cent in 2022 to 82.1 per cent in 2023, and 74.6 per cent from January to July 2024. Meanwhile, the share of Chinese suppliers such as Sensortech, Cheng Tech, and Huawei is expanding. From January to July 2024, their combined market share totalled 13.3 per cent.

In the context of cost reduction and efficiency improvement and fierce competition, automakers are choosing suppliers on price. As technology advances and its mass production and application accelerate, Chinese radar suppliers are providing more front radars (including 4D radar) and corner radars (including 4D radar), scrambling for bigger market share.

For example, in October 2023, Sinpro completed the industry's first fully automatic 4D imaging radar production line, expected to produce 800,000 units annually after operation. In August 2024, Sinpro's self-developed automotive dual-chip 4D imaging radar SFR-2K entered mass production, supporting models such as Nio's ET9 and the Onvo L60.

Chuhang Tech has a production base in Anqing City, with annual capacity of more than 1.8 million radars (including 4D radars); Cheng Tech's total annual capacity of radars is up to over 13 million units (including 4D imaging radars).

## Four development trends of radar technology

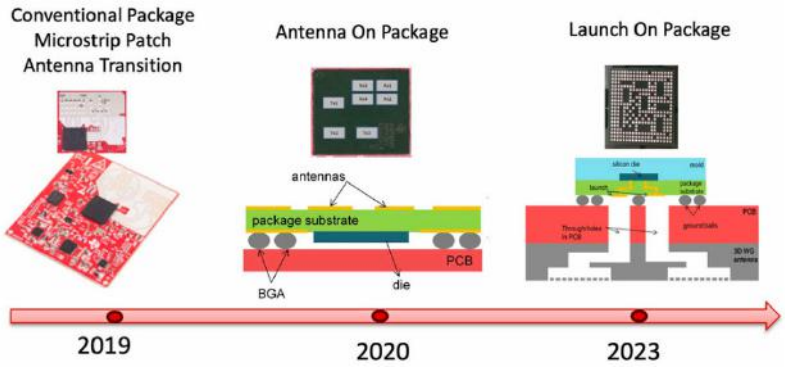
The upstream end of the automotive radar industry chain is still dominated by non-Chinese chip and module vendors; top names include Infineon, ADI, NXP, ST, TI, Renesas, Onsemi, Arbe, and Uhnder. Chinese radar suppliers are also developing rapidly, and quite a few startups have emerged; notable names include Calterah, Osemitech, and SenardMicro.

## Antenna efficiency

In radar design, the first thing to consider is how to improve antenna efficiency. The industry is developing from microstrip antenna to waveguide antenna technology, which reduces energy loss; suppliers like Bosch and Continental use it. Air waveguide antennas have even lower capacity loss. Suppliers working to promote it include Aptiv (4D radar FLR4+), and XretinAI Technology; compared with microstrip antennas of the same size, their Quasi-Air Integrated Waveguide (AIW) antennas enable a gain boost of about 5 dB.

## RF stages to antennas optimised coupling

Antenna packaging technology is evolving toward AiP (antenna in package), to reduce antenna feeder loss. A few companies such as Calterah have launched ROP (radiator-on-package) technology, which uses solder balls to connect RF signals, has higher channel isolation, and offers a longer detection range and a wider FOV.




The more advanced LoP (launch on package) technology is being used by Continental in the production of their sixth-generation radar chips. LoP enables the electromagnetic waves emitted by the radar to propagate directly from the chip through the air waveguide, avoiding the higher energy loss and high cost caused by etching the antenna on the circuit board, achieving low cost and improving the radar's detection performance.

## Interference mitigation

Signal anti-interference is also a factor that must be considered. For example, one of the unique benefits of Uhnder's single 4D digital imaging radar chip with 192 virtual channels (12T 8 × 2R) is the use of advanced digital code modulation (DCM) technology, which can effectively improve the anti-interference performance of the radar system and resist interference signals in various complex environments. To prevent multiple vehicle radars from transmitting RF signals at the same time in overlapping frequency bands, Continental uses an intelligent time synchronization approach to prevent interference between the vehicle radars. To avoid interference from radars on other vehicles when the vehicle is traveling, coding is added to the waveform and decoding is performed as the echo signal is received.

## Satellite architecture helps create more cost-effective 4D radar products

In radar design, the most critical thing is that the signal processing architecture is developing towards satellite architecture. This distributed architecture can leave most of the signal processing and object recognition tasks to the central processing unit, thereby exploiting the computing power and computing resources of the central processing unit. The higher computing power and more software processing are a solution to stable detection and other problems of radars in the case of a complex scenario and multiple objects.

For example, the Altos RF Series is a non-computing front-end radar module, a radar solution deeply integrating domain controllers, with price about half of similar models with processors. It uses the computing resources of the intelligent driving domain controller or the central domain controller to generate high-quality point clouds.

The Altos V2 shown here is the world's first mass-produced 4-chip cascaded imaging radar based on TI's TDA4. It boasts:

High angular resolution: 1.38° azimuth × 1.43° elevation (antenna array intrinsic)

Long detection range: cars @ 400m, pedestrians @ 200m

Precise velocity detection: no ambiguity in single frame from -400km/h to +200km/h

Dense point cloud: up to 6000 points per frame @ 15 fps

Extreme low noise: a fraction of that from competing products

Simple and robust: single PCB, 3 parts total.

Yet satellite radars also face challenges, including:

- Processing large amounts of data increases the hardware cost of domain controllers
- Mainstream high-power chips' support and compatibility with radar algorithms needs to be improved and optimized
- OEMs now still mainly use the object-level data output by satellite radars and have technical difficulties in using ADC data directly. They are reluctant to switch between satellite radars and traditional radars, and more actual cases are needed to promote market acceptance.

SENSING BUSINESS

# Sensing Business Newsbites

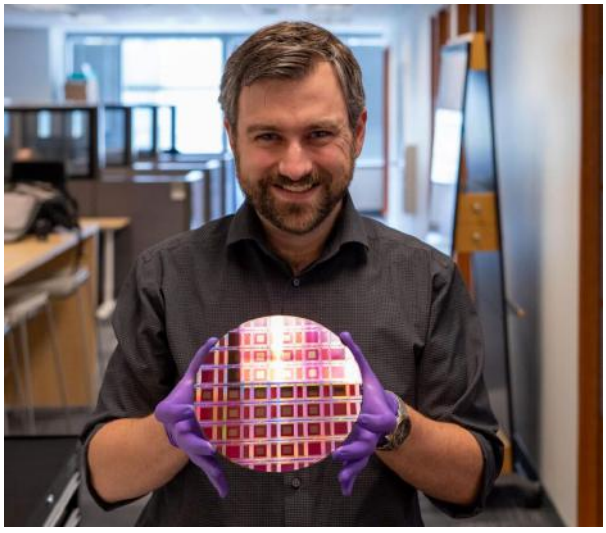


**Lyft to launch Mobileye-powered robotaxis**

Lyft plans to bring fully autonomous robotaxis, powered by Mobileye, to their app “as soon as 2026” in Dallas, Texas, with more markets to follow. The news came a day before Lyft reported their Q4 financial results, coinciding with Waymo’s preparations to launch a commercial robotaxi service with Uber in Austin, Texas and, later, in Atlanta, Georgia.


**RoboSense forecasts 2024 annual revenue surge**

RoboSense released their earnings forecast, predicting annual revenue of between C¥1.63bn and C¥1.67bn in 2024, indicating a year-on-year growth of approximately 45.5 to 49.1 per cent. They anticipate a net loss attributable to shareholders of around C¥430m to C¥520m, representing a reduction of about 88 to 90.1 per cent versus the same period in 2023.



**Lumotive mulls opportunities after series B funding**

Lumotive, the US-based optics startup that has developed beam-steering metasurfaces for applications including 3D sensing and lidar, has raised $45m in a series B venture funding round. Lumotive received support from new investors including Swisscom Ventures, East Bridge, EDOM, Grazia, Hokuyo, and TSVC. Lumotive said the oversubscribed round also saw the return of existing investors including Gates Frontier, MetaVC Partners, Quan Funds, USAA, and HiMax.


**Forvia Hella moves Asia HQ to New Shanghai Office**

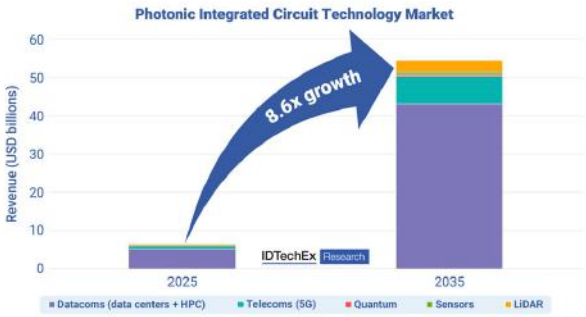
Forvia Hella has moved their Asian headquarters, comprising the Hella Corporate Center Asia and Hella Trading (Shanghai), to the Fu Building at Forvia's China Headquarters in Shanghai's Minhang District. This will facilitate collaboration across the different business groups and create greater synergies while maintaining operations as an independent company. The move was made to improve agility in responding to market dynamics, promote resource sharing, and strengthen the company's ability to deliver exceptional services to the dynamic Chinese market, they have said.


**Hesai deepens collaboration with BYD**

Hesai Technology has expanded their intelligent-driving partnership with BYD. Large-scale production and vehicle integration are set to commence shortly. By 2025, over ten BYD models will be equipped with Hesai lidars. In 2024, BYD once again led the global new energy vehicle market, achieving sales of 4.27 million units, a year-on-year increase of 41.26 per cent. BYD is making significant strides in intelligent mobility, with Chairman and President Wang Chuanfu announcing a C¥100bn investment to advance integrated vehicle intelligence.


## Omnitron in series A funding for MEMS development

Omnitron Sensors has raised over $13m in series A funding led by Corriente Advisors, with L'attitude Ventures also participating. This investment will expand Omnitron's engineering and operations teams to speed the production of their first product, an affordable MEMS step-scanning mirror. Omnitron streamlines MEMS sensor production, enabling critical applications in AI data centers, long-range lidar for autonomous vehicles, XR headsets, and precision laser spectrometry for methane detection.




## PIC Market to Balloon by '35: IDTechEx

Photonic integrated circuits (PICs) are tiny optical systems manufactured with technology used in the electronic integrated circuit industry. The importance of PICs in high-speed communication within artificial intelligence data centers is leading to rapid growth in demand for PIC-enabled transceivers to help machine learning models grow ever larger. Anticipation of the skyrocketing requirement for AI data centers is the key to IDTechEx's prediction in their latest report, "Silicon Photonics and Photonic Integrated Circuits 2025-2035: Technologies, Market, Forecasts," that the PIC market will reach $54bn by 2035.

## Innoviz trims workforce to strive for profitability

Innoviz has announced an adjustment to their operations aimed at extending the company's cash runway and enhancing progress towards profitability and free cash flow generation. The company will reduce focus on segments where development efforts have been completed. Consequently, the company's workforce will be reduced by approximately 9 per cent. This realignment, along with other measures, is expected to result in cost savings of around $12m in 2025.



**LeddarTech's First LeddarVision OEM Design Win**

LeddarTech has announced that a leading commercial-vehicle OEM has chosen LeddarVision for OE build into a 2028-model vehicle. Revenue from this partnership will start in 2025 for engineering services, with per-vehicle royalties expected by late 2027. The project begins immediately, pending final agreements.


**Bosch mm-wave radar shipments top 100m**

Bosch's 2024 cumulative global shipments of millimeter-wave radar exceeded 100 million units, of which over 30 million for the Chinese market. Bosch introduced their fourth-generation mm-wave radar to China in 2014, with first application in Geely vehicles for single-radar automatic emergency braking (AEB) systems. Bosch noted that this technology laid a foundation for the proliferation of autonomous driving functionalities and significantly boosted demand for millimeter-wave radars in the Chinese market.

LIDAR TECHNOLOGY

# Lidar technologies Newsbites


## Hesai features in BYD 'God's Eye' ADAS

BYD's new 'God's Eye' ADAS has been launched, and the automaker is promising to equip all their models, even the least-expensive ones, with this latest-iteration system. This will obviously have a huge impact on the accessibility of advanced driving assistance features in the EV world.

BYD's Chairman, Wang Chuanfu, emphasized the company's extensive resources dedicated to intelligent driving. BYD has been developing their system with a massive cloud-based database of vehicles, and a team of 5,000 R&D engineers focused purely on intelligent driving. The company's daily ADAS training mileage of 72 million km in 2024 clearly shows its commitment to making the technology better. Wang Chuanfu predicts that intelligent driving will become a must-have feature for car buyers within the next few years.

The 'God's Eye' system comes in three tiers, each designed for different vehicle models and price ranges:

- God's Eye C, the entry-level system, targets BYD's more affordable vehicles, including the Seagull hatchback that starts at C¥69,800 (around $9,550) in China. The Qin Plus DM-i, and the Seal 05 DM-i, both starting under C¥100,000 (about $13,690) will get the new ADAS as well. This low-priced system uses a three-camera cluster behind the windshield and is powered by the DiPilot 100, boasting 100 TOPS of computing power. It also includes 12 cameras (three front-view, five panoramic, and four surround-view), five mmWave radars for 360-degree perception, and 12 ultrasonic radar sensors. DiPilot 100 supports $L^2$ features like highway NOA (navigate-on-autopilot), lane changes, and remote self-parking. BYD aims to expand city NOA to this class of vehicles via OTA updates.

- God's Eye B adds a Hesai ATX lidar unitfor more robust 3D mapping and object detection. It is powered by the DiPilot 300 with 300 TOPS of computing power. The camera, radar, and ultrasonic setup is similar, but the lidar integration and software calibration allow for expanded autonomy features. This enables advanced city navigation, improved obstacle detection in poor visibility, and potentially more sophisticated parking manoeuvres. God's Eye B will be featured in Denza and Fang Cheng Bao vehicles, as well as some upper BYD models.

- God's Eye A, at the top of the line, has three Hesai ATX lidarspowered by the DiPilot 600 with 600 TOPS of computing power. DiPilot 600 provides panoramic coverage of the vehicle's surroundings. Designed for premium models like the Yangwang U9, DiPilot 600 can reportedly handle complex urban scenarios and high-speed highways with greater redundancy and 360° scanning.

## The Hesai ATX lidar

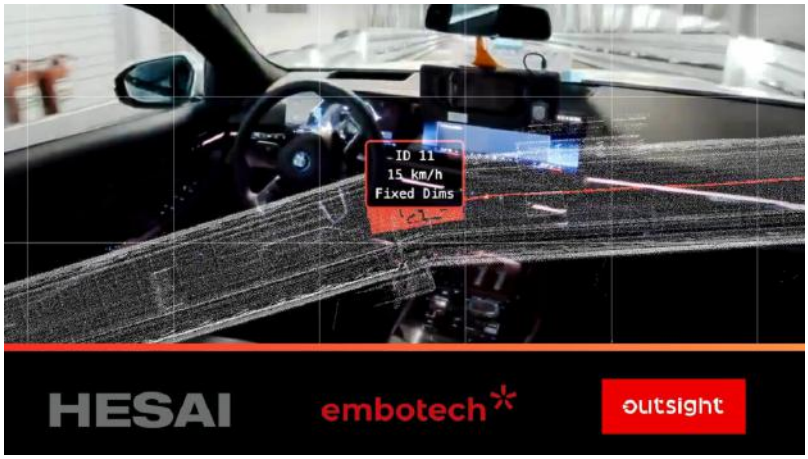

### DeepSeek R1: The AI behind DiPilot

At the core of BYD's DiPilot system is DeepSeek's R1 model, a large-scale AI engine originally developed for language processing but adapted to handle the demands of real-time driving. Unlike traditional rule-based computer vision, R1 uses neural networks to interpret the environment, detecting and classifying objects—cars, pedestrians, lane markers—in varied weather or lighting conditions. Beyond perception, R1 can support decision-making and help predict possible maneuvers such as lane changes or braking. It can also spot road hazards and make split-second risk assessments. By integrating DeepSeek's R1 simulated-reasoning model, BYD gains AI-powered perception that handles complex urban scenarios, from traffic light recognition to chaotic intersections.

DVN comments

A key element of BYD's approach is its in-house-developed Xuanji architecture. This architecture, described as "one brain, two ends, three networks, and four chains," integrates a central processor, cloud AI, vehicle-side AI, the Internet of Vehicles, 5G and satellite networks, sensor chain, control chain, data chain, and mechanical chain. The Xuanji architecture connects to the Deepseek R1 LLM, enhancing AI capabilities even further.

## Outsight Software Powers Automation Across Automotive Factories




Lidar enables BMW's latest 5- and 7-Series models and their 0MINI Countryman to navigate autonomously to their finishing areas—showcasing the remarkable potential of this technology and spatial intelligence in modern manufacturing. As part of a commitment to automation, BMW began testing automated in-plant driving (AFW) at their Dingolfing plant, the largest in Europe. Using Outsight's RAD solution and feedback from advanced lidar sensors, new vehicles autonomously travel over one kilometre from assembly halls, through test courses, to finishing zones. This boosts efficiency and safety, as Outsight's RAD processes 60 million lidar data points per second to guide approximately 300 cars daily at Dingolfing.

In collaboration with Embotech and Hesai, Outsight has played a pivotal role in delivering BMW's Automated Vehicle Marshalling (AVM) systems, an essential component of AFW.

Embotech's autonomous driving expertise, Hesai's lidar sensors, and Outsight's perception software form the backbone of this innovative system. The technology ensures precision and safety as vehicles autonomously navigate BMW facilities without human intervention.

### Expanding the Impact of lidar Technology

With CE certification secured, BMW plans to roll the technology out across factories in Leipzig, Regensburg, Oxford, and the upcoming Debrecen facility in Hungary. This initiative combines autonomous driving technologies with real-world industrial applications. The implementation will contribute to BMW's goal of logging millions of autonomous test kilometres within their production network over the next decade. Lidar's utility in dynamic environments extends beyond manufacturing, with proven applications in large venues such as airports and stadiums to enhance crowd management. Outsight's roadside autonomous driving (RAD) solution, which is hardware-agnostic, processes up to 200 million data points per second and allows integration with sensors from multiple manufacturers. This versatility enables swift hardware upgrades, ensuring future scalability.

## A Vision for the Future of Autonomous Manufacturing

Embotech, Outsight and Hesai have successfully collaborated for several years, jointly advancing lidar and perception solutions for autonomous driving.

"The combination of Outsight's sophisticated lidar software platform and Hesai's reliable lidar sensors perfectly complements Embotech's autonomous driving expertise," says Dr. Alexander Domahidi, CTO and Founder of Embotech. "This collaboration ensures the highest standards of safety and efficiency in BMW's automated vehicle operations."

This latest strategic collaboration builds upon a strong foundation, enabling the companies to provide best-in-class technology for AVM, which is safety rated, fulfilling the highest performance and availability requirements.
According to Raul Bravo, President and co-founder at Outsight, “Our collaboration with Embotech, Hesai, and BMW highlights the increasing maturity of lidar technology, particularly the software underpinning it. Its application to real-world factory conditions demonstrate its ability to enhance industrial safety and efficiency, while underlining the importance of a comprehensive framework to realise the potential of autonomous driving.”

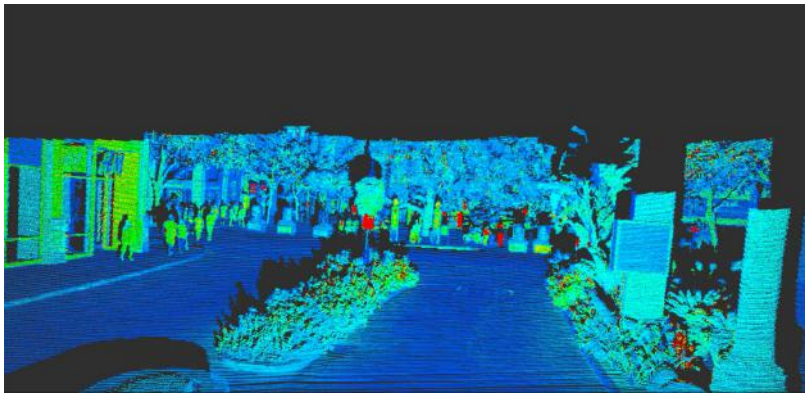
“Hesai is proud to partner with Embotech and Outsight to deliver cutting-edge lidar technology for BMW’s Automated Vehicle Marshalling (AVM) system,” says Dr. David Li, CEO and Co-founder of Hesai Technology. “This state-of-the-art technology demonstrates the high level of precision and safety offered by our lidar and Outsight's perception software for Embotech’s autonomous driving solutions. We look forward to continuing our collaboration and bringing this technology to more factories around the world.”

The integrated solution is now actively supporting the marshalling of newly manufactured vehicles through various stages of the production and logistics process in three BMW facilities. This deployment marks the initial phase in a global rollout to multiple plants across Europe and North America.

### DVN comments

The collaborating companies, Embotech, Outsight and Hesai, have been working together for several years to advance perception and autonomous driving solutions. This collaboration provides state-of-the-art technology for autonomous vehicle marshalling, meeting the highest performance and availability requirements. Such a system could be implemented for valet parking applications within public or private parking areas, at a condition that incoming vehicles are electric vehicles equipped with automated steering and longitudinal control systems (e.g., automated parking system).

# Seyond's Directional Lidars for Security Applications



In evaluating their current automobile dedicated Lidars, Seyond has identified several reasons a directional lidar-based security system may be more effective than rotational lidar:

## Precision and Stability

One of the primary advantages of directional lidar is its resolution. Unlike rotating lidar, which relies on spinning to collect data, directional lidar focuses on specific, predefined areas. This targeted approach allows for higher resolution in detection, essential for identifying minor movements or small objects that rotating systems might miss. In security settings, where every detail is critical, having a sensor that provides consistent and precise data is a notable benefit.

## Faster System Response Times

Time is of the essence in security applications—the faster the system can detect a potential threat, the quicker the response. Directional lidar can rapidly scan and re-scan specific areas with higher resolution, providing clear updates. This capability is invaluable for real-time threat assessment and response, ensuring that security teams remain one step ahead.

## Reliability

Certain directional lidar systems, such as those from Seyond, are specifically developed for automotive applications and undergo rigorous automotive qualification processes. This ensures enhanced durability and lower maintenance requirements, particularly important in outdoor or harsh environments where continuous operation is paramount and frequent maintenance is impractical. Rotating lidar, in contrast, can be prone to wear and tear due to weaker quality control processes. The required larger motors for handling heavier loads further increase costs and complexity, potentially leading to system downtimes and increased maintenance costs.

## Enhanced Coverage and Customizability

Directional lidar offers greater flexibility in customizing security coverage. While rotating lidar provides a full 360-degree view, this can result in inefficient data collection, capturing unnecessary or irrelevant information. Directional lidar can be strategically positioned and programmed to focus on vulnerable or high-priority areas, optimizing data collection and reducing the computational load and storage requirements.

## Integration and Scalability

In modern security ecosystems, seamless integration of various technologies is crucial. Directional lidar easily integrates into existing security infrastructures, including advanced video analytics and access control systems, enhancing their overall effectiveness. Additionally, as security needs evolve, directional lidar systems can be scaled or reconfigured with minimal disruption, offering long-term adaptability and future-proofing investments in security technology.

## Directional lidar Helps Reduce False Alarms

False alarms are a critical concern in any security application. There are two major issues surrounding false alarms: the significant costs associated with dispatching teams and equipment to the site for each false alarm and the potential "fatigue" in response teams, which can lower efficiency. Camera-based systems are susceptible to false alarms due to environmental factors, sensitivity settings, visual limitations, limited perspective, and non-human activity.

Seyond's directional lidar, including their Falcon K, Robin W, and Robin E1X, feature ultra-high resolution, ensuring precision in detection. This level of precision is vital in security environments, where accurately differentiating between objects based on size, shape, and movement patterns reduces the number of false alarms caused by non-threatening movements. With fewer false alarms, Seyond lidar systems streamline security operations, allowing personnel to concentrate on genuine alerts, improving efficiency and response times.

Rotational lidar systems, however, scan their laser beams across a broad field of view, reducing both resolution and depth perception, making it more challenging to clearly identify specific threats or intruders.

Directional lidar excels in focusing on specified areas of interest without requiring 360-degree monitoring. Seyond's directional Falcon lidar offers dynamic focusing features for better target tracking, even in challenging conditions. Additionally, Seyond's streamlined design allows for concealed installation, avoiding the exposure and aesthetic drawbacks of rotating lidar.

Rotational lidar's need for larger motors and moving parts increases power consumption and susceptibility to malfunction, whereas Seyond's semi-solid-state directional lidar systems have minimal moving parts, ensuring longevity and lower maintenance needs. Seyond's Falcon K has passed a series of standard reliability tests, demonstrating unwavering performance stability even in the most demanding environments.

### DVN comments

Reliable and durable directional lidar systems, like those from Seyond, are designed for automotive applications and undergo rigorous qualification processes, ensuring increased durability and reduced maintenance requirements. Seyond's directional lidar systems, such as the Falcon K, Robin W, and Robin E1X, offer high accuracy in detection, reducing the number of false alarms caused by non-threatening movements. Such sensors are designed to address the specific requirements of traffic monitoring and security surveillance, which could potentially expand Seyond's market with its Falcon K, Robin W, and Robin E1X portfolio.

CAMERA TECHNOLOGY

# Camera technologies News

## Ambarella SoCs for Gauzy Camera Monitoring System


Gauzy, a global supplier of light and vision control technology, has incorporated a CVflow system-on-chip (SoC) from AI semiconductor company Ambarella into the Gauzy Smart-Vision camera monitoring system (CMS), to enhance road safety for drivers of commercial vehicles. The Gauzy solution, based on Ambarella's CV2FS SoC, is already operational in Ford Trucks. CMS replaces traditional side and/or rearview reflective-glass mirrors with high-resolution cameras mounted around the vehicle. Also known as e-mirrors, these systems include a live video stream to interior displays, giving drivers a wider view of their surroundings and significantly reducing blind spots, thus improving overall safety and visibility on the road.

The Smart-Vision CMS, based on Ambarella's CVflow AI accelerator, features self-learning and predictive capabilities. These include adaptive manoeuvre lines that are displayed while a vehicle is in motion and during trailer calibration to give drivers better visibility of their surroundings, as well as the ability to quickly analyse large amounts of data and imagery for significantly reduced latency and real-time visibility.

Moreover, the Smart-Vision system is programmed to automatically detect potential road hazards before they are encountered, greatly reducing the possibility of accidents or fatalities, according to the company. The system also provides clear lines of sight via high image quality, across a wide variety of weather or lighting conditions. The company says that the Smart-Vision CMS's surveillance mode deters theft and vandalism, is compatible with various truck models and configurations, and can be easily integrated into existing fleets.

"It's highly rewarding for us to be working so closely with Ambarella, a global leader in edge AI vision processing, to advance the functionality and quality of Smart-Vision," stated Eyal Peso, CEO of Gauzy. "World-renowned brands like Ambarella trust Gauzy to utilize their proprietary technology to its full potential, and partner with us because of the success our products can have in saving lives and reducing costs. We recognized early on the monumental impact AI will have in redefining mobility and are proud to have already developed what we believe is the most sophisticated AI-powered ADAS solution on the market. We believe that enhancing our Smart-Vision system with Ambarella's CVflow AI SoCs, which provide industry-leading AI performance per watt, provides OEMs with an innovative solution as part of their ongoing efforts to improve the safety of their fleets."
Peso added, "Despite the tremendous advancements we have already made in ADAS, we are still at the beginning of the AI-ification of vision control. We will continue to innovate and improve the quality of our products, to retain our competitive edge and produce for our shareholders. We are energized by the strong demand for our Smart-Vision CMS and believe that we are well positioned to capitalize on the renewed emphasis on safety in urban and intercity transport."

Among the biggest differentiators of Gauzy's Smart-Vision system with Ambarella's CVflow SoCs is its high-performance image processing capability. This is required for lowering the amount of latency experienced and activating vulnerable road user (VRU) detection, object classification, data recording and video streaming.
Ambarella's CVflow SoC architecture enables Gauzy's development teams to fine-tune various parameters, resulting in superior image quality and highly accurate color and contrast representation, which is essential for minimizing driver fatigue.

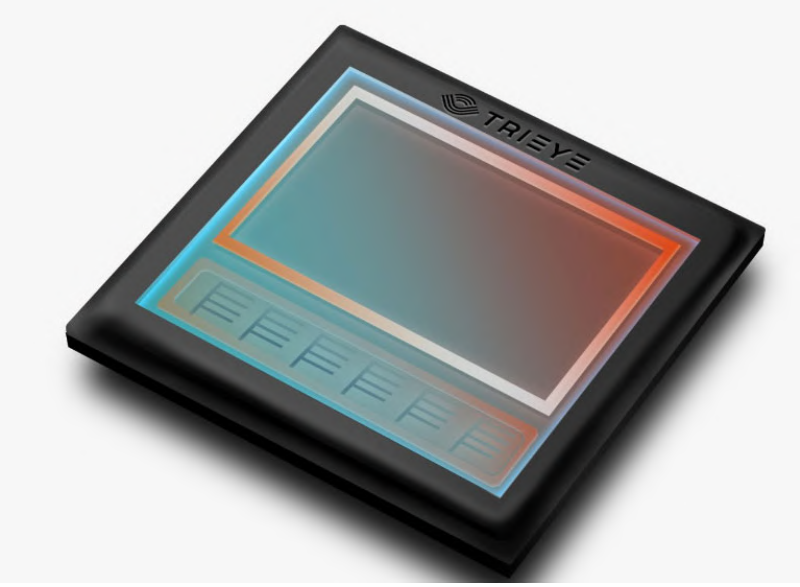
"Our partnership with Gauzy demonstrates the power of what's possible when two forward-thinking organizations with similar values work together to tackle industry challenges," commented Fermi Wang, president and CEO of Ambarella. "We were motivated to help Gauzy and its OEM customers address the millions of road traffic fatalities that are estimated to occur each year, and we believe the Smart-Vision CMS, with our CVflow AI SoCs, has the potential to drive this number lower. There is universal support for making our roadways safer, and we are pleased to help play a role in this effort through the application of our technology."

The Smart-Vision CMS has passed strict homologations and certifications for safety, including UNECE R10, R46, R118, R151, and automotive cybersecurity standards including UNECE R155 and R156.

## DVN comments

Gauzy's Smart-Vision system, integrated with Ambarella's CVflow AI system-on-chip (SoC), offers several specific benefits for vulnerable road users (VRUs) in urban environments. CMS replaces traditional rearview mirrors with high-resolution cameras, providing a wider view and significantly reducing blind spots. The system has predictive and self-learning capabilities, allowing for better visibility and rapid analysis of real-time data. This includes adaptive manoeuvring lines displayed during vehicle movement and trailer calibration, giving drivers better visibility of their surroundings.

# TriEye High-Resolution SWIR Image Sensor Enters Production




TriEye is bringing SWIR to mass production with their Raven, the world's first CMOS-based SWIR sensor. By solving fundamental constraints in manufacturing, TriEye's unique sensor design provides high-resolution, low power consumption, small form factor, and a 99-per-cent price reduction compared to current InGaAs technology.

TriEye's full-stack solution allows any machine vision system to operate and deliver image data and actionable information even under the most challenging visibility conditions. Leveraging our deep expertise in device physics, process design, electro-optics, and system engineering enables us to create SWIR systems that can support a wide range of mass-market applications.

The Raven TES200 is a 1.23 Megapixel CMOS-based SWIR Sensor that has a resolution of 1,236H × 960V pixels. It has a global shutter in a 2/3" optical format that delivers a frame rate of 120 fps (12 bit), 150 fps (10 bit) and 180 fps (8 bit).

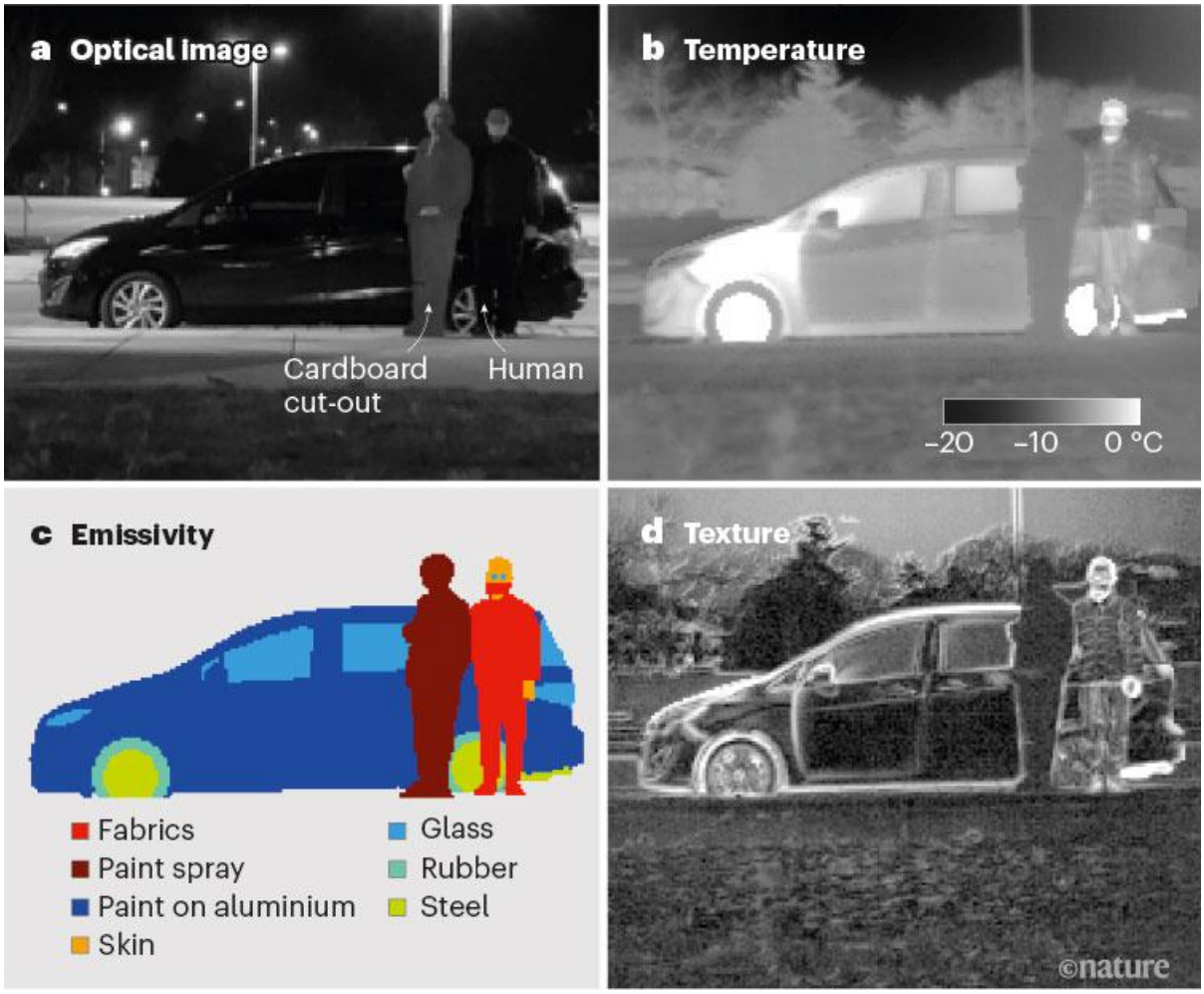
This SWIR sensor has a pixel pitch of 7 × 7 µm and wavelength range of 700 to 1,650 nm. It has a quantum efficiency of 60 per cent at 1,245 nm and full well capacity of 440,000 e-. This SWIR sensor has a conversion gain of 0.0064 DN/e- and dark current of 100 pA. It has 8/10/12-bit ADC with an imager size of 8.98 × 6.72 mm and optical cross talk of 0.5 to  2 per cent.

The Raven TES200 supports monochrome color filter and RAW-8, -10, and -12 output formats. It has horizontal & vertical binning or sub-sampling and configurable region of interest (ROI) & windowing. This SWIR sensor has a configurable 24-bit parallel interface (up to 1,25 MHz) and fast I2C (up to 1 Mbps) control interface. It has external frame synchronization and up to 8 general purpose outputs & triggers. This SWIR sensor has an integrated temperature monitor and 512 bit of OTP memory. It requires a DC supply voltage of 1.2 V or 3.3 V, and dissipates 500 mW of power.

## DVN comments

TriEye's sensor can be integrated into the SEDAR platform, which provides high-resolution, long-distance detection capabilities. Its robust performance across various environmental conditions, from bright sunlight to complete darkness, ensures consistent reliability. This adaptability aligns perfectly with the stringent requirements outlined in the new US AEB regulation, FMVSS 127, ensuring dependable operation in diverse scenarios.

## IR Imager Merges AI, Thermal Physics




Heat-assisted detection and ranging (HADAR), a patent-pending thermal imaging technology from Purdue University, combines infrared (IR) imaging, machine learning, and thermal physics to visualize target objects in the dark as if it were broad daylight. According to its developers, the technology could have an impact on par with lidar, sonar, and radar, by enabling fully passive, physics-aware machine perception.

Traditional sensors that emit signals, such as lidar, radar, and sonar, can encounter signal interference and risks to eye safety when they are scaled up. “Each of these agents will collect information about its surrounding scene through advanced sensors to make decisions without human intervention,” Professor Zubin Jacob said. “However, simultaneous perception of the scene by numerous agents is fundamentally prohibitive.”

Video cameras designed to work in sunlight or with other sources of illumination are impractical for use in low-light conditions. Traditional thermal imaging can sense through darkness, inclement weather, and solar glare. However, ghosting — a thermal imaging effect that causes hazy images lacking in material specificity, depth, or texture — makes it difficult to use traditional thermal imaging for object detection.

“Objects and their environment constantly emit and scatter thermal radiation, leading to texture less images famously known as the ‘ghosting effect,’” researcher Fanglin Bao said. “Thermal pictures of a person’s face show only contours and some temperature contrast; there are no features, making it seem like you have seen a ghost. This loss of information, texture, and features is a roadblock for machine perception using heat radiation.”

### Textnet deep neural network

Using a computational approach and machine learning, HADAR reconstructs the target's temperature, emissivity, and texture (TeX), even in complete darkness. The TeX information is presented in the HSV color space to form the text view for the AI model known as Textnet.

Textnet is a deep neural network designed to perform inverse text decomposition. When provided with a hyperspectral cube of data, Textnet decomposes it into three maps: a temperature map, an emissivity map for materials in the materials library, and thermal lighting factors. Textnet is trained using a physics-based data reconstruction loss function and can be trained with direct supervision if the ground-truth TeX decomposition is available.

A significant challenge for the researchers was the limited availability of high-quality training data. However, the physics-based loss function allowed them to compensate for limited data and facilitate effective learning for Textnet. By disentangling information within the complex heat signal, HADAR operates effectively in total darkness as if it were daylight.

The team tested HADAR TeX vision using an off-road nighttime scene. HADAR ranging at night was found to outperform thermal ranging. In daylight, it showed an accuracy comparable with RGB. Automated HADAR thermography reached the Cramér-Rao bound on temperature accuracy, surpassing existing thermography techniques.

The researchers developed an estimation theory for HADAR and addressed photonic shot-noise limits depicting information-theoretic bounds to HADAR-based AI performance.

Additional enhancements to HADAR will include improving the size of the hardware and the data collection speed, the researchers said.

"The current sensor is large and heavy, since HADAR algorithms require many colours of invisible infrared radiation," Bao said. "To apply it to self-driving cars or robots, we need to bring down the size and price while also making the cameras faster. The current sensor takes around one second to create one image, but for autonomous cars we need around 30- to 60-Hz frame rate, or frames per second."

Initially, HADAR TeX vision will be used in automated vehicles and robots that interact with humans in complex environments. The technology could be further developed for agriculture, defence, geosciences, health care, and wildlife monitoring applications.

### DVN comments

Traditional technologies like lidar, radar, and sonar can encounter signal interference and eye safety risks when amplified. HADAR overcomes these limitations by using a passive approach. HADAR technology combines infrared imaging, machine learning, and thermal physics to detect and localize objects. HADAR reconstructs the temperature, emissivity and texture of targets even in complete darkness, exceeding existing thermographic techniques in accuracy. The technology is initially intended for autonomous vehicles and robots but could be developed for other applications like traffic surveillance and security.

RADAR TECHNOLOGY

# Radar technologies News

## TI Edge AI Radar Sensor, Audio Processors Facilitate New In-Car Experiences

Texas Instruments recently introduced new integrated automotive chips to enable safer, more immersive driving experiences. The supplier's AWRL6844 60GHz mm-wave radar sensor supports occupancy monitoring for seat belt reminder systems, child presence detection and intrusion detection with a single chip running edge AI algorithm, enabling a safer driving environment. With TI's next-generation audio DSP core, the AM275x-Q1 MCUs and AM62D-Q1 processors make premium audio features more affordable. Paired with TI's latest analog products, including the TAS6754-Q1 Class-D audio amplifier, engineers can take advantage of a complete audio amplifier system offering. TI showcased these devices at the 2025 CES in Las Vegas.

"Today's drivers expect any car – entry-level to luxury, combustion to electric – to have enhanced in-cabin experiences," said Amichai Ron, TI's Senior VP of Embedded Processing. "TI continues to provide innovative technologies to enable the future of the automotive driving experience. Our edge AI-enabled radar sensors allow automakers to make vehicles safer and more responsive to the driver, while our audio systems-on-chip elevate the drive through more immersive audio. Together they create a whole new level of in-cabin experiences."

Automakers are gradually designing in more sensors to enhance the in-vehicle experience and meet evolving safety standards. TI's edge AI-enabled AWRL6844 60GHz mmWave radar sensor enables engineers to incorporate three in-cabin sensing features to replace multiple sensor technologies, such as in-seat weight mats and ultrasonic sensors, lowering total implementation costs by an average of $20 per vehicle.

The AWRL6844 integrates four transmitters and four receivers, enabling high-resolution sensing data at an optimized cost for OEMs. This data feeds into application-specific AI-driven algorithms on a customizable on-chip hardware accelerator and DSP, improving decision-making accuracy and reducing processing time. The edge intelligence capabilities of the AWRL6844 sensor that help improve the driving experience include these examples:

While driving, it supports occupant detection and localization with 98% accuracy to enable seat belt reminders.

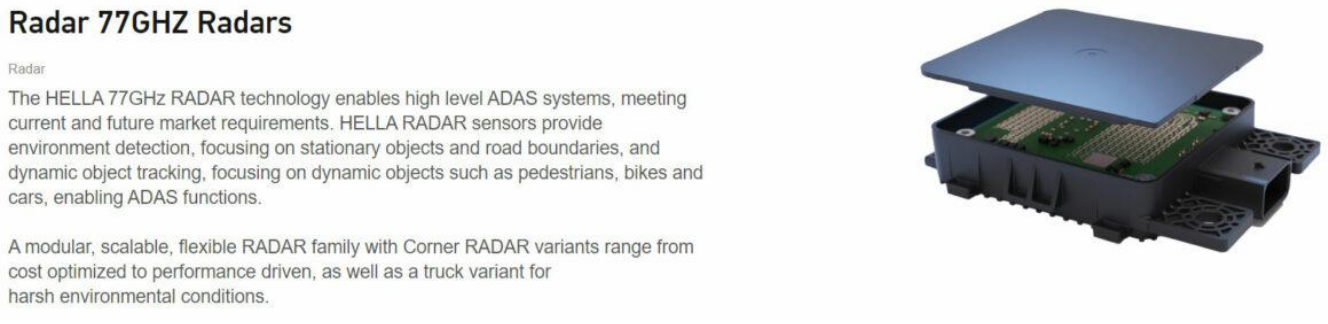
After parking, it monitors for unattended children in the vehicle, using neural networks that detect micromovements in real time with over 90-per-cent classification accuracy. This direct sensing capability enables OEMs to meet 2025 European NCAP design requirements.

When parked, it adapts to different environments through intelligent scanning, reducing false intrusion detection alerts caused by car shaking and external movement.

DVN comments

**TI's 60GHz AWRL6844 radar sensor supports occupancy monitoring for seat belt reminder systems, child presence detection, and intrusion detection with a single chip using an AI algorithm at the edge, enabling a safer driving environment. The AWRL6844 radar sensor, featuring a 4TX/4RX antenna structure like traditional ADAS radars, integrates AI and can replace multiple sensor technologies, reducing implementation costs by about $20 per vehicle.**

## Forvia Hella Awarded for 77GHz Radar




Forvia Hella has received the ZhILU Award from Auto Observer for their innovative fifth-generation 77GHz radar. This radar offers 360° environmental detection and supports levels L1 to L5 in autonomous driving. As demand for ADAS systems increases, Hella has started mass production of these radar sensors at their Shanghai plant.

"We're delighted that Forvia Hella's fifth generation of 77GHz radar has earned recognition from the esteemed local media outlet 'Auto Observer' and industry experts. This accolade not only underscores our technical strength but also validates our foresight and proactive approach to local industry trends", said Xia Jingchu, Hella's China Director of Radar Products. "Forvia Hella remains dedicated to meeting market demands, offering innovative, high-quality, and competitive products to support the advancement of autonomous driving in the Chinese automotive industry."

The supplier has been deeply engaged in the research and development and manufacturing of corner radar for more than 20 years. Leveraging deep expertise in this field, FH's fifth generation of 77GHz radar is based on a radar system chip with RF-CMOS technology and processes, a specific array antenna design, and uses MIMO technology, bringing a wider field of view for both horizontal and vertical directions. Featuring a modular architecture, it offers versatile chip combinations with varying interfaces and computing power specifications, catering to diverse architectural requirements from $L^1$ to $L^5$. The radar offers three operational modes—near-range, short-range, and medium-range—enabling comprehensive coverage across various application scenarios in both near-field and far-field environments. Thanks to the enhanced antenna miniaturization facilitated by increased radar beam frequency, FH's fifth generation of 77GHz radar delivers significantly improved performance in a more compact size, facilitating effortless installation on vehicle fronts, rears, and sides to achieve 360° all-round environmental detection.

Hella radar sensors have undergone rigorous testing and validation in the Chinese market, with specialized performance optimization tailored to the region's complex urban and harsh weather conditions. Therefore, they demonstrate exceptional stability across various scenarios, providing high-quality raw data to bolster research into autonomous driving strategies.

FH has established a localized supply chain for their fifth generation 77GHz radar in China, demonstrating robust local production capabilities. Their Shanghai electronics plant boasts extensive automated production lines.

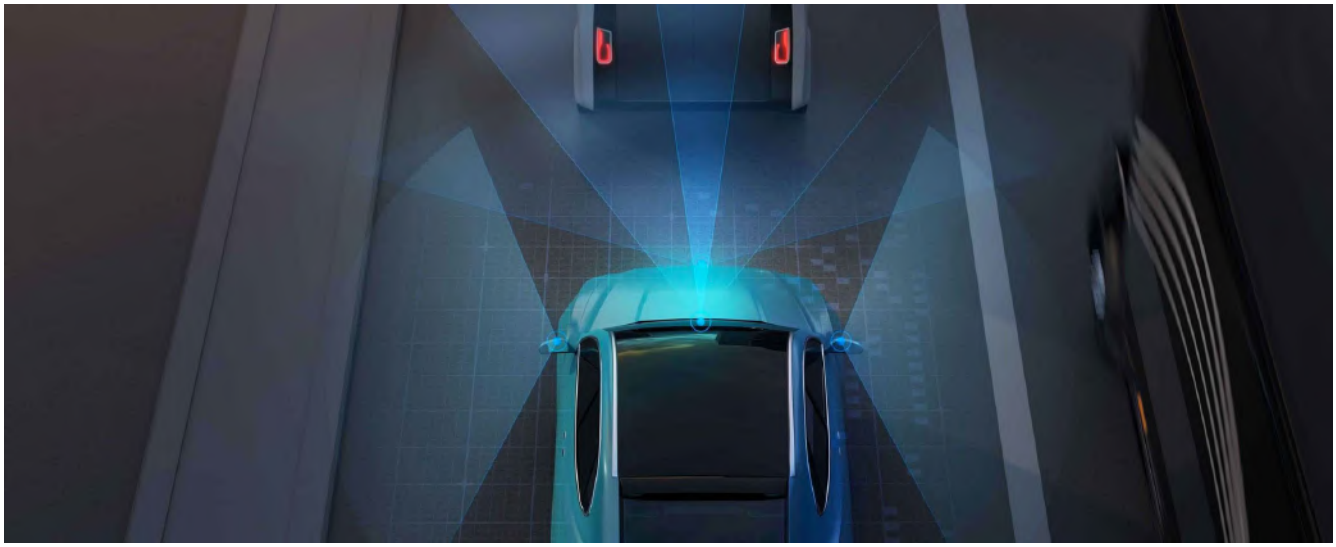
Unlike traditional radar systems, high-resolution radar (HRR) offers improved accuracy in detecting distances, angles and velocities, enabling multiple objects tracking and precise obstacle detection. This function is vital for automated driving at $L^3$ and above, where safety and situational awareness are paramount. One primary advantage of the high-resolution radar is its performance in various environmental conditions, including low-visibility scenarios such as fog or heavy rain, where cameras and lidar struggle. This ability allows autonomous vehicles to navigate complex situations safely. Advancements in high-resolution radar will likely focus on refining sensor fusion algorithms and integrating data from multiple sensor types such as cameras and lidar. This will create a more comprehensive understanding of the vehicle's surroundings, improving decision-making processes. The development of wider aperture radar systems will further elevate resolution and accuracy for better differentiation between various objects, such as pedestrians and cyclists. As these technologies evolve, high-resolution radar will play a pivotal role in achieving higher levels of autonomy and ensuring safer roadways for all users.

## DVN comments

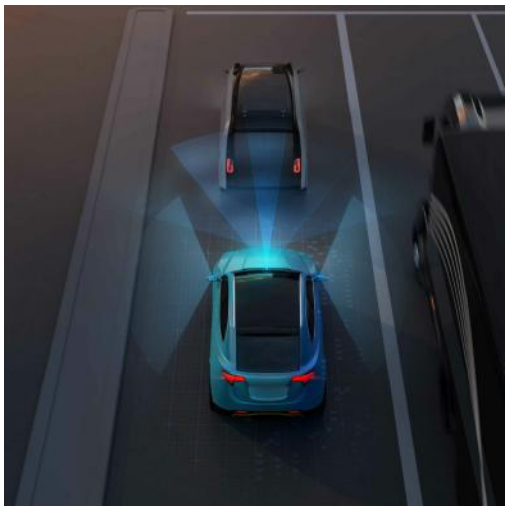
This standardized radar structure uses RF-CMOS technology and an adaptable antenna design, providing three native modes of operation: short-range, medium-range, and long-range, allowing for comprehensive coverage in various scenarios. The radar has been optimized for China's complex urban conditions and harsh weather conditions. Forvia Hella's Chinese supply chain for this radar demonstrates robust local production capabilities (now radar SoCs can be also supplied by local silicon chips suppliers).

REGULATIONS

# Sensing Architectures / Integration / Regulation News



## NHTSA Delays FMVSS 127 In-Force Date, Grants Reconsideration Petitions



The US National Highway Traffic Safety Administration has delayed the effective date of its automatic emergency braking (AEB) rule, Federal Motor Vehicle Safety Standard Nº 127, to give the Trump Administration more time to review the mandate. The rule's effective date of 27 January has been pushed back to 20 March.

The Alliance for Automotive Innovation (Auto Innovators) has filed a lawsuit against NHTSA saying the rule is flawed and impracticable (find DVN analysis of the filing **here**). FMVSS 127, in its present form, will require AEB and pedestrian AEB to come standard by September 2029 on all passenger cars and light trucks weighing up to 10,000 pounds. By then, AEB must stop and avoid rear-end crashes at up to 62 miles per hour and detect pedestrians in daylight and at night. The standard will require AEB to engage at up to 90 mph when a collision with a lead vehicle is imminent, and up to 45 mph when a pedestrian is detected.

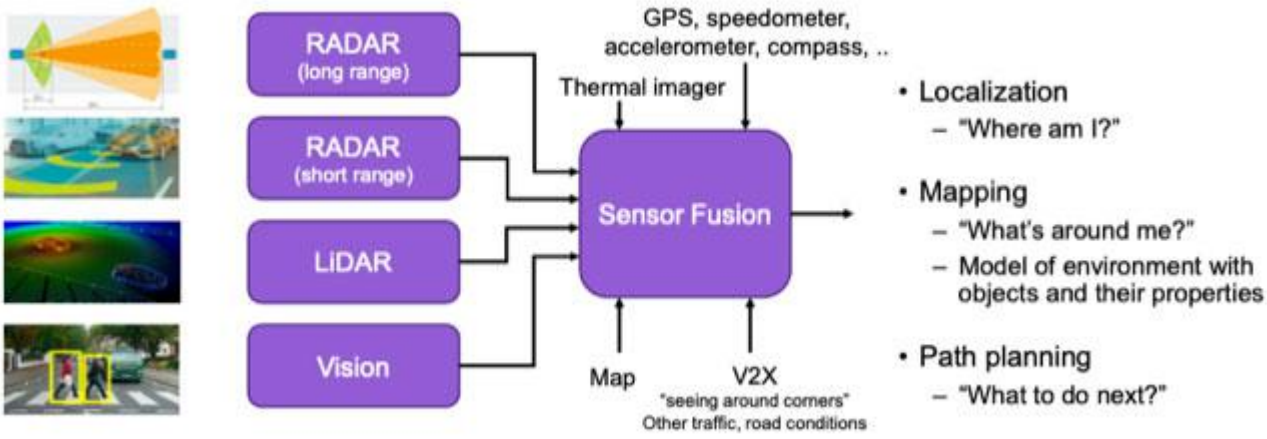
In a June 2024 letter to Congress, John Bozzella, Auto Innovators president and CEO, wrote NHTSA's new standard is "practically impossible with available technology" and that "NHTSA's own data shows only one tested vehicle met the stopping distance requirements in the final rule". He recommended NHTSA "adopt a standard already in place in Europe that detects a potential forward collision, provides a driver warning and automatically engages the braking system to avoid a collision — or mitigate its severity — through the use of existing crashworthiness systems designed to better protect road users".

Bozzella continued: “Automakers and suppliers provided NHTSA [with] a series of technical adjustments during the comment period to correct the deficiencies and achieve our shared safety goals. Despite partnering with automakers on AEB in 2016, this time the agency rejected the industry’s feedback. …after a decade of shared and substantive work on AEB and a billion dollars invested, NHTSA inexplicably changed course and issued a rule that automakers indicated was not feasible with widely used braking technologies.”

A timeline of the rule implementation and Auto Innovators’ actions regarding it was provided in a previous release:

- May 31, 2023 — NHTSA proposed AEB rulemaking for new vehicles.
- Aug. 14, 2023 — Auto Innovators submitted comments to NHTSA on its AEB proposal.
- April 29, 2024 — NHTSA finalized its AEB rule with a no-contact requirement.
- June 24, 2024 — Auto Innovators filed a petition with NHTSA asking it to reconsider the April 29, 2024 rule citing the “impracticability” of NHTSA’s no-contact requirement “including the likelihood that this requirement will lead to unsafe unintended consequences…”
- Nov. 12, 2024 — In a post-election letter to President-elect Donald Trump, Auto Innovators wrote that the 2024 AEB rule is “inconsistent with regulations implemented in other parts of the world and urges the incoming administration to ‘re-open the AEB rule…’”
- Nov. 25, 2024 — NHTSA “effectively denied” the association’s June 24, 2024 petition for reconsideration and the no-contact requirement.

## ADAS Adds Complexity to Automotive Sensor Fusion




Sensor fusion in automotive designs integrates multiple sensors into a single chip, routing data intelligently. The goal is to combine information from cameras, radar, lidar, and other sensors for a comprehensive view inside and outside vehicles. Typically, this occurs in zonal controllers or central compute modules that collect sensor data and transmit it to a central unit. The location of sensor fusion and the sensors involved vary based on vehicle architecture and manufacturer approach.

There are two main options for fusing together sensors in a vehicle. “In the zonal ECU, sensor fusion can be performed, which is really a smart switch,” Ron DiGiuseppe, automotive IP segment manager at Synopsys, said. “The other option is to do the sensor fusion on the central compute module, where the data extraction could occur in that central compute module.”

Which option to use is typically is based on cost. “If you do the fusion in the zonal ECU, that application is a chip — an SoC with multiple ports,” DiGiuseppe said. “It handles all kinds of different data types — CAN, MIPI, etc. They all go through that zonal ECU and then get transferred to central processing so it can be done in the zonal ECU. But generally, it’s passed through to the central compute, and that would have a high-performance automotive in-car Ethernet, as well as long channel MIPI ports. Most of the CAN would get converted in the ECU, and the CAN packets would go to the zonal ECU to get extracted and then encapsulated into Ethernet to be transferred back to the central compute.”

A high-speed in-vehicle network, often using automotive Ethernet, is crucial for effective sensor fusion. Modern cars use 1 Gbps Ethernet, with 10 Gbps systems coming soon. This network enables quick data transfer between sensors, zonal controllers, and the central processor.

The fusion process itself often involves specialized hardware and software. For example, unified DSPs (Digital Signal Processors) can handle data from different sensor types, such as radar, LIDAR, and cameras. Additional accelerators may be used for specific functions like Fast Fourier Transforms (FFT) or computer vision tasks. So, while this is more complex than the original sensor fusion concept, but it’s also more mature.

“Like all new technologies there was a rush to a solution,” said David Fritz, vice president of hybrid and virtual systems at Siemens Digital Industries Software. “Almost by definition, every solution was new and differentiated. Today, sensor fusion is well understood. Frankly, we’re seeing smarter perception stacks that make sensor fusion less of a concern. Lidar, radar, camera, and inertia all interplay, but the trend with sensing is more intelligence at the sensor, which makes fusion much less of a concern.”

What gets combined varies by use case. Robert Schweiger, group director automotive solutions at Cadence, described one scenario in which a vision processor also processes radar data, as well as some AI functions. “I want to analyze the point cloud and identify, based on the points, what kind of object I have in front of me,” he said. “There are commercially available cores, with the instruction set of radar and vision cores integrated in a single core. That means it can do lidar, radar, and vision in this one single core.”

Or perhaps the application is a very demanding sensor system with the latest high-definition sensors that that deliver a ton of data to the processor. “You may have an accelerator on top of it to support a DSP and accelerate, for instance, FFT functions on top,” Schweiger noted. [If the processor] includes an AI base functionality up to 2 TOPS, that means with those two cores you have a very powerful system. Some people need more AI performance, so you need a neural processing unit, where one instance can be scaled up to 80 TOPS, and many of those instances that you can put together on a multi core system can be scaled up to hundreds of TOPS or a thousand TOPS.”

All these processors on a chip needs to be connected, as well, which requires a network-on-chip. “A NoC is needed to connect our different IPs into a subsystem, which eventually becomes a chiplet,” Schweiger said.

Then, for the sensor fusion, assume there is a sensor stack. “You have a camera radar, you have a 4D imaging radar for high resolution, you have a front camera, and you have another camera to the side or to the back,” Schweiger said. “These are the different sensor modalities, and now you want to fuse together everything. The corner radar maybe a low-end or mid-range type of radar, so it’s not so demanding, but the 4D imaging radar is a very demanding type of sensor. There’s lots of data, which means you need a lot of processing here. For the front camera, it’s the same thing. The smart camera in the front is normally the most powerful camera, and it is doing a lot of pedestrian detection, image analysis, filtering, and so forth. There may also be a low-end camera for the back. So how does the system look for the sensor fusion? [Our approach is a] unified DSP that can do radar, lidar and baseline AI.”

The same instance used for the radar also can be used for the camera, whether it's the front camera or the back camera. "There, we process vision time of flight and AI," he noted. "From the upper DSP, we generate a radar PCL (point cloud), and generate a vision point cloud for the lower part, so we can fuse the front camera and maybe side camera together, or corner radar and front radar. We fuse it together in the core. If we need more performance, we add FFT as an accelerator, or another accelerator that can accelerate FFT functions, as well as computer vision functions."

## Smarter sensors

Increasingly, this will include machine learning, as well. "The types of sensors being used to achieve the granularity of control for an autonomous platform or a heavily driver-assisted function, and the types of data they're using, are inherently more complex than traditional sensor measurements that you might find in an adjacent sector like the process industry or the medical field," explained Andrew Johnston, director of quality, functional safety and cybersecurity at Imagination Technologies. "Those sensors might still — and have done — sensor fusion for decades. They've relied less on machine learning, and arguably that's still evolving, but the types of transducers they use are inherently simpler. So you might end up with simple look-up tables and cross-reference algorithms."

In the automotive landscape, the big change comes down to visual perception and making structure from motion. "To do that well, you need an array of different sensor types," Johnston said. "You can functionally deliver autonomy with single sensor types, but with mixed results. And because these are high-integrity functions, i.e., safety-critical, to employ levels of redundancy and diversity is a good thing. At the system level, you want to fuse sensors from camera, radar, lidar, ultrasound, and then even couple that to more traditional sensors, like light sensors or temperature sensors. You're doing that to try and understand what the operational environment is. The problem is that's an inherently complex functionality and technology space, and at the semiconductor level, it's even more challenging. In an ideal world, every semiconductor supplier wants to try and build one product that can satisfy a number of use cases. We try not to make use-case specific products because that will have a very niche application, and customers may still not choose your product. So the balancing act that IP and semiconductor providers have is trying to assess use cases systematically and understand what could be done in the hardware software space before they figure out what the transistors on a chip need to do."

What this means in the automotive space is a lot of machine learning, and a lot of high-bandwidth requirements on machine learning. "You want to execute these algorithms in real-time, and what that means is you're doing a lot of different types of complex matrix multiplications and data fusion, and you ideally want to do that on a singularity and to do that quickly," he said. "The reason why it's doing this quickly is it has to make control-system-based decisions, just like a human driver would in the loop. We do it naturally, and we are analog, so you're trying to represent an analog world and an analog controller in a digital domain. It's quite an interesting challenge philosophically."

## Transition to SDV, zonal architectures

As the automotive industry transitions toward software-defined vehicles and zonal architectures, the approach to sensor fusion is evolving. OEMs are working to integrate these new systems with their existing architectures, which presents significant challenges. The goal is to create a more centralized and scalable system that can be easily updated and expanded as technology advances.

It's worth noting that the specific implementation of sensor fusion can vary significantly between manufacturers, with some opting for more centralized approaches while others distribute processing across multiple nodes in the vehicle.

“Today, sensor fusion is the process of combining data from multiple sensors to create a more comprehensive view of the environment, and typically not based on generative AI and deep machine learning,” said Ted Karlin, senior director for marketing and applications sensing of compute and connectivity products at Infineon Technologies. “In the future, more applications using generative AI and deep machine learning with sensor fusion algorithms will become significantly more intelligent. With generative AI, the sensor fusion process will become more adaptive as these models can synthetically fill in data gaps, simulate potential outcomes, and therefore predict and react to changes in real time. They also will have greater contextual awareness, as historical context can be a part of the algorithm, along with environmental factors and situational awareness for higher-quality sensor fusion outputs. Lastly, machine learning can become more personalized as generative AI could utilize a specific person’s monitoring or diagnostics to drive personalized conclusions.”

Others agree. “The power of fusing imaging radar with camera is well understood,” said Adiel Bahrouch, director of business development for silicon IP at Rambus. “Radar, for example, is not able to read signs, and you cannot train it to read signs. It cannot see different colors, red, color, blue color, while the camera does. You can train cameras with AI to recognize signs, people, objects, lanes and so forth. When you combine those characteristics with all the good things that radar can bring to the table, you can have a very powerful system which can easily beat lidar. Lidar is yet another technology which has a lot of good things, but very, very expensive. For very high autonomous levels, I don’t see that the camera can do the job alone since the camera, in dark or very poor weather conditions, can introduce some safety issues. Radar doesn’t have the capabilities of camera in terms of resolution, image detection, and pattern recognition, but when you combine those two, you have a very powerful system that can bring autonomous driving forward.”

As far as where this resides in the vehicle, Bahrouch points to the evolution of the E/E architecture as a starting point. “The traditional vehicles have their own domain-based architectures where all the ECUs and all the sensors are connected, which means the fusion is a big challenge. That architecture doesn’t support those types of activities. But with the shift toward zonal based architectures, where sensors that are located in the same corner are combined under one big processor, the zonal processor helps to gather all the information from different sensors to start doing the fusion. That means the information is processed locally, so it’s zonal, or through the high-speed Ethernet backbone that collects all the information from different angles and starts doing the fusion centralized in the center of the vehicle. I don’t know which one is going to be the mainstream approach, whether it’s going to be at the edge or on the zonal SoC, or the brain, or a combination of those. Will it do pre-process before all the information is combined? This is an area that is now evolving. It’s quite a new area, so not all the stakeholders are disclosing their strategy.”

There is widespread agreement, however, that the continued integration of lidar, radar, and camera sensors will make vehicles safer. “Advanced sensors will make a significant impact on ADAS solutions by providing more accurate data and improving safety manoeuvres, from lane-keep-assist to auto parking and braking,” said Wayne Lyons, senior director of marketing for AMD’s Automotive Segment. “As the number and different types of sensors within the vehicle, such as cameras, radar and lidar, continues to rise each year, pioneering companies like Waymo have already logged millions of autonomous miles in vehicles that leverage all three technologies. In addition, emerging EV companies in China are leveraging advanced sensors like lidar to differentiate their safety offering in the fiercely competitive EV market. To achieve the real-time performance required so the various sensor data can be used in real-world driving situations, developers will need a flexible architecture that can provide the necessary performance with functional safety, all on a single chip.”

## 4D radar

The move to 4D radar will further increase the amount of sensor data to be fused, Synopsys' DiGiuseppe said. "The transition to 4D radar is increasing the number of DSPs, and it's also being channelized. Instead of just one-reflection data, you can have channelized data, so you get multiple radar reflections using virtualized channels. That provides a more extensive data set, so it's no longer just a single radar bounce-back. Since it's channelized, it's closer to the lidar approach. In lidar technology, you get a point cloud, which typically gives you much more data. That's one of its advantages over radar. Lidar gives you higher resolution. Plus, you have 128- and 256-channel lidar. Radar is starting to add channelization, too, so the radar data is getting higher resolution, and that allows you to identify objects using a radar data set, just like a camera image."

AI processors are used here to identify the image. "It's a dog, it's a tree, it's a person," DiGiuseppe said. "Radars are starting to be able to give you that capability, as well, although certainly not as high-resolution as a camera system because it's a different problem to solve. While cameras do have some limitations, like at night, under darkness, or in rain or fog or heavy snow, and they still have gaps in terms of object detection identification. Radar now provides these data sets that are a good complement to cameras under those conditions where cameras are not ideal, so the amount of information that is being extracted from these 4D radars is much more useful for ADAS systems. You can do object detection using radar now, which is new.

Conclusion While sensor fusion technology has advanced significantly, its implementation in automotive systems continues to evolve. The trend is toward more intelligent, distributed processing, along with standardized communication of object data. These concepts seem clear, although implementation is still evolving. Nevertheless, as vehicles in development today get closer to hitting the road, further details should emerge from the OEMs as to the direction this technology is heading.

**EVENT**

# Upcoming DVN Sensing & Application events

### Program with speakers

**APRIL 9th - Part-I: ICE BREAKER**

| | |
|---|---|
| 06:00 PM | Welcome Cocktail & democars' test |
| 07:30 PM | Standing Dinner on exhibition platform |

**APRIL 10th - Part-II: CONFERENCE**

| | |
|---|---|
| 08:15 AM | Opening |
| 08:30 AM | Keynote(s) - NHTSA Requirements & Challenges<br>• **General Motors** – Jodi Allen<br>• **MAGNA** - Jan Erik Källhammer, Director Visual Enhancement and Cognitive Systems |
| 09:00 AM | Q&A: NHTSA Requirements & Expected Challenges |

**Session 1- Performance Lighting & Vision Systems**

| | |
|---|---|
| 09:10 AM | • **FORD** (tbc)<br>• **STELLANTIS** - Emilie Robb, Senior Manager AI & ADX (tbc)<br>• **VALEO** – Joseph Thompson, CTO-US<br>• **OMNIVISION** (speaker tbd) |
| 10:10 AM | PANEL-1: Opportunities for Vision Systems |
| 10:25 AM | Coffee Break |

**Session 2 - Performance of Radars & Fusion**

| | |
|---|---|
| 11:00 AM | • **APTIV** – Philippe Troia, CTO-EU<br>• **PERCIV.ai** - Andras Palffy, Co-Founder<br>• **ZENDAR** - Antonio Puglielli, VP of Engineering<br>• **HELLA** - (speaker tbd) |
| 12:00 PM | PANEL-2: Benefits of FUSION Systems |
| 12:15 PM | Lunch break & democars' test |

## Session 3 - Performance of IR Cameras

**01:50 PM**

- **ADASKY** - Bill Grabowski, CEO
- **FLIR** - John.Eggert, CTO
- **OBSIDIAN** - John.Hong, CEO

## Session 4 - Performance of Lidars

- **ROBOSENSE** - Scott.Skelton, CTO-US
- **CEPTON/KOITO** - Henri Haefner, Senior Dir. Product Management
- **Light IC** – Dr Jie Sun, Co-founder

**03:20 PM** **PANEL-3: Benefits of the new technologies**

**03:35 PM** **Coffee Break & democars' test**

## Session 5 - Performance validation, Simulation/Calibration

**04:25 PM**

- **ANSYS** - Lionel Bennes, Lead Product Manager & Aaron Talwar
- **BURKE PORTER** – Brunno Moretti, President ADAS Solutions

**04:55** **Q&A**

**05:15** **CLOSING REMARKS**